# STUDY OF PERCHLOROETHYLENE STILL BOTTOM RESIDUE WASTES ASSOCIATED WITH THE ALBERTA DRY CLEANING INDUSTRY

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## ACKNOWLEDGEMENTS

The success of this study was largely due to the full cooperation given by the owners and operators of dry cleaning establishments who participated, and provided information and samples.

Special thanks are extended to the Alberta Professional Dry Cleaners Association for their involvement, efforts and interest in making the study a success.

## ABSTRACT

During the summer of 1986, the Waste Management Branch of Alberta Environment undertook a study to determine the waste handling practices of the dry cleaning industry in Alberta. Tetrachloroethylene, more commonly known as perchloroethylene or "perc", is the cleaning solvent used by the majority of the dry cleaning industry. This solvent, and still bottoms resulting from the recovery of these solvents, are listed in Schedule II, Section II of the Transportation of Dangerous Goods Regulations (TDGA). Under Alberta legislation they will be considered a hazardous waste and require proper disposal.

The study focused on still bottom residue wastes generated by the industry and involved inspecting over 170 dry cleaners across Alberta and collecting 97 samples of still bottom residues from various dry cleaners. These samples were analyzed for perc concentration.

Laboratory analysis revealed perc concentrations ranging from 0.02% to 65.0% perc by weight. Materials identified in Schedule II, List II with a 9.2 designation, the material would have to contain less than 100 ppm of the listed contaminant to be considered a "non-environmental" problem material. Perc is identified in Schedule II, List II of TDGA and as such, cartridges, sludges and diatomaceous earths would have to contain less than 100 ppm of perc to not be regulated by TDGA. All the samples in the study had concentrations of perc in excess of 100 ppm.

It is estimated that 28,000 - 33,000 gallons of still bottom residues are disposed of in landfills and dumps across Alberta annually. In addition, approximately 16,000 - 19,000 filter cartridges containing perc residue are similarly disposed of on a yearly basis. Finally, an estimated 80,000 - 100,000 lbs/yr. of filter powder residues, also containing perc, are disposed of in the same manner.

Dry cleaning operations in Alberta were shown to generate hazardous wastes which must be regulated under the Transportation of Dangerous Goods Act and disposed as a hazardous waste.

## INTRODUCTION

In response to concerns expressed by the Waste Management Branch regarding wastes associated with the dry cleaning industry, a program was initiated during the summer of 1986 to identify the chemical and waste handling practices of this industry. Since little or no work has been

performed in this area either in Alberta or Canada, the Waste Management Branch of Alberta Environment was entering a relatively unknown area when it initiated this project. The focus was on tetrachloroethylene (perchloroethylene).

Tetrachloroethylene and "sludges from the recovery of these solvents in degreasing operations" as well as "the still bottoms from the recovery of these solvents using distillation" are listed in Schedule II, Section II of the Transportation of Dangerous Goods Regulations and are characterized as Waste Types I and II, respectively. As a result, wastes associated with the dry cleaning industry are considered to be hazardous and as such, must be either treated to render them non-hazardous or eventually be shipped to a proper hazardous waste treatment facility, such as the one at Swan Hills, Alberta. Therefore, emphasis was placed on gathering data which would provide a characterization and inventory of dry cleaning wastes, a description of their present and past waste disposal practices, and laboratory analysis of still bottom residues to determine the remaining perchloroethylene concentrations.

## DRY CLEANING PROCESS

The basic steps in the dry cleaning process are similar to those of laundering using water, except that dry cleaning is a waterless process in which clothes are cleaned in a non-aqueous, organic solvent rather than with soap and water. In the washing step, clothes are placed in an enclosed, perforated cylinder called a dry cleaning unit similar to the laundry washing machine. Solvent is then added and the garments are agitated in the solvent by motion of a paddle or wheel. One or two solvent baths may be used by the cleaner, although most commercial cleaners use only one bath. Occasionally, detergent may be added to the solvent in the one-bath system to help remove water-soluble soils.

After the washing has been completed, solvents used in the wash cycle are drained and the garments are then spun at a high speed to extract much of the solvent. After extraction, the used solvent is filtered to remove insoluble impurities and is then returned to the system. Filtration is followed by periodic distillation of all or part of the solvent to remove the soluble impurities such as oils, fats and greases that were once present in the dirty garments.

After the clothes are washed and the solvent has been extracted, the clothes are tumble dried. This drying step differs with the two types of machines. With the transfer machines, the operator must transfer the clothes to a dryer-reclaimer. As the clothes are being transferred from the washer-extractor to the dryer-reclaimer, the perc-laden air is drawn away from the operator by an exhaust fan. The fan pulls the air into the washer and dryer doors and away from the operator when the doors are open. Current OSHA regulations require machines equipped with fans.

During the drying cycle, much of the evaporated solvent is recovered with a solvent-reclaiming dryer. Depending on the nature of the fabric cleaned, the extracted garments may retain up to 45% of the solvent, by weight. Heated air is circulated over the clothes to vaporize the solvent which is then recovered in a water-cooled condenser. The condensed solvent is separated from the water extraction and recycled to the system. After the drying step,

which lasts about 15-20 minutes, the dryer is set to "vent". In this final step of the dry cleaning process, fresh air is circulated through the dryer to cool or aerate the clothes. During this aeration process, also known as deodorization, the airstream and perc vapors are either vented to a carbon adsorption system which recovers the perc from the airstream, or they are released to the outside environment.

Two types of machines exist for the purpose of washing the clothes, they are the transfer and dry-to-dry units. The transfer unit, as the name implies, requires transferring of the clothes from the washing unit to a separate (drying) unit for drying. Washing and extraction are accomplished in the transfer unit, while the drying portion of the cleaning cycle is performed in a solvent reclaiming dryer. The dry-to-dry machines perform all three steps. The clothes are put in dry and removed dry, hence the name dry-to-dry.

Commercial dry cleaners as well as the industrial cleaners use either type of machine, whereas all coin-operated perchloroethylene machines are of the dry-to-dry variety. Each machine has certain advantages over the other. With the dry-to-dry machine, the major disadvantage is that it can typically handle half as many loads per day as a transfer operation. In a transfer operation, washing and drying can occur simultaneously since each step is being performed in a separate machine. In a dry-to-dry operation a given load must be washed and dried in the same machine, which ties up the machine for a longer period of time before another load can be started. For this reason, many dry cleaners also have an external dryer present with their dry-to-dry units.

Another disadvantage of the dry-to-dry unit is that the machine is hot at the end of the drying cycle, which allows the incoming solvent for the next cycle to pick up a large amount of heat. This can increase solvent vapor losses. As well, hot solvent can adversely affect the machine seals and some delicate fabrics. However, with the newer "cold dry" or "refrigeration" units on the horizon, this disadvantage should be nullified.

In spite of these disadvantages, dry-to-dry machines remain the preferred choice of the industry. The reason is that dry-to-dry units do not require worker contact with solvent-laden clothes during their movement from the washing to the drying cycles. This minimizes the release of perc vapor into the work area and enables the work area to comply more easily with Occupational Health and Safety Administration requirements for maximum perc concentrations in the work environment.

## SOLID WASTES

There are three types of solid wastes generated from the dry cleaning industry. These wastes are used cartridge filters, filter wastes, and the still bottom residues.

During the washing cycle, the perc is passed through a filter for the removal of suspended matter and dyes. The cartridge type filter usually consists of a perforated outside metal liner with paper on the inside. This paper filter is re-used until the pressure drop across the filter becomes large enough to warrant its replacement. These cartridge filters are normally just drained in their housing and then discarded with trash.

The other type of filter system consists of a diatomaceous earth or "filter powder" which forms a coating on a series of tubes within a filter housing and through which the perc flows. The filter is regenerated by backwashing and removing the filter powder precoat and adding a new precoat. This backwash contains diatomaceous earth, activated carbon, suspended matter

filtered out of the perc, and a large amount of perc. The backwash may be heated in a "muck cooker" to drive off the perc, which is then condensed and recovered. Since this type of system is labor intensive and requires an experienced operator, many of the dry cleaning plants surveyed have switched from this type of filter system to the cartridge type.

Distillation is used to separate perc from soluble impurities such as oils and fats. To prevent the build-up of these impurities, periodic distillation of all or a portion of the perc is required. With industrial cleaners, the garments cleaned are usually very oily and dirty. Filters would have to be replaced frequently when washing such dirty clothes, for this reason industrial cleaners rely solely on distillation of their perc to maintain clean solvent in their machines.

After filtration, the solvent is directed to a tank designated for distillation, while the operator uses clean solvent from a second tank for washing purposes. During distillation, the solvent is heated with steam to a temperature which enables the water and solvent to vaporize. This leaves the impurities behind. The vapours leave the still and enter a condenser, where they pass over water-cooled coil surfaces and condense (see Figure 1). From here, water is separated from the perc using a separator. The heavier solvent settles to the bottom, while the water is drawn off the top and discharged to the sewer system. The amount of solvent discharged with the wastewater depends on the operation and age of the equipment and the efficiency of the separator. However, small quantities of solvent dissolve in the water and are discharged with the wastewater. Clean solvent is returned to the clean solvent tank and is ready for re-use.

The impurities left behind, or still bottom residues, are a thick, dark brown residue which contains oils, fats, dirt and perc. Depending on the operation and age of the equipment, a wet or dry sludge is removed. The amount of perc left in this residue depends on a number of factors, such as how long the perc was distilled, the efficiency of the distillation unit, and the distillation method utilized. Some dry cleaners may further treat this sludge with a "muck-cooker", which further heats the sludge to volatize any remaining perc.

## SAMPLE COLLECTION AND RESULTS

Approximately 180 dry cleaning establishments across Alberta were visited with a total of 97 samples being taken. The samples were comprised of three consistencies: light oily still bottom residues; heavy, viscous still bottom residues; and diatomaceous earth (filter powder). Most of the samples (67) were of the light oily nature. Of the 97 samples taken, 94 were tested for perchloroethylene concentrations, 2 for fluorocarbon and 1 for petroleum solvent.

Samples were either scooped or funnelled into 50 ml scintillation viles equipped with teflon coated plastic screw-on lids. The viles were then labelled as to date, and location of sampling. This information was also recorded in a sample log book. Disposable latex gloves were worn at all times during sampling. The samples were then placed in a sampling box and delivered to a laboratory for analysis.

Most of the samples were taken from still bottom residues stored on site. A typical commercial dry cleaner will clean out the still every two weeks and put the residue in a 5 gallon container. These samples provide a good representation of what is typically being discarded. However, occasionally it

# Perchloroethylene Still and Condenser

***During distillation, the contaminated cleaning solvent is heated, permitting solvent and water to vapourize. These vapours leave the still and enter a condenser where they pass over water-cooled coil surfaces and condense.***

*Source: Operating Tips for Better Dry Cleaning, PPG Industries.*

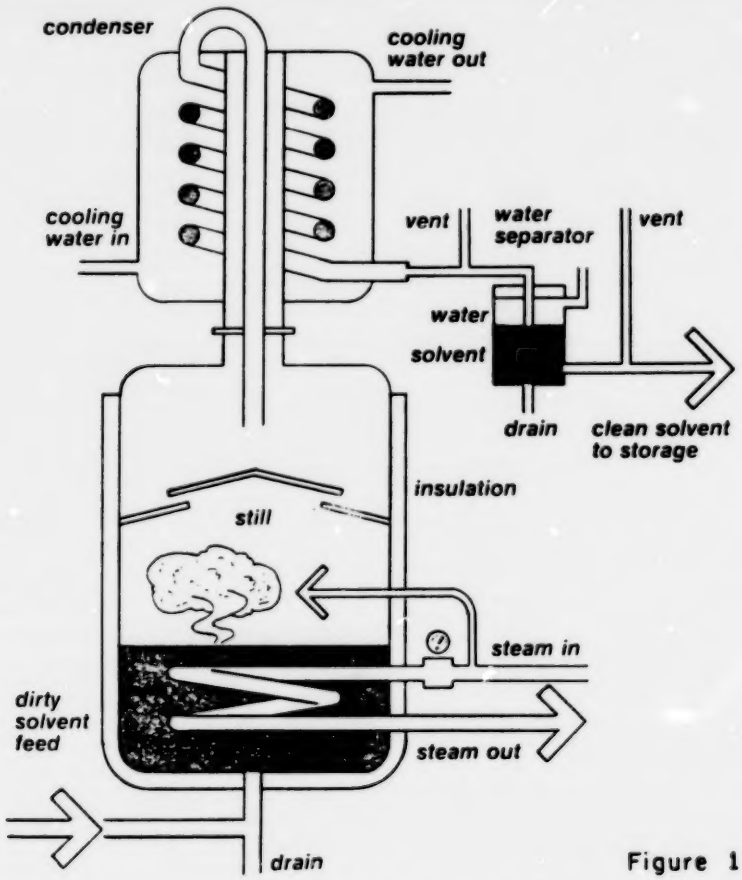


Figure 1

was not possible to obtain a sample from a still bottom residue storage container and a sample was taken directly from the still by skimming off the top when the door was opened. In addition, some larger operations, such as the industrial dry cleaners, store the wastes in either large storage tanks or 45 gallon drums. The tanks may be pumped out once a month. Samples taken from these two sources may yield deceiving perc concentrations.

Further samples taken from these two sources were light oily residues. A sample taken from one cleaner, from an underground storage, tank yielded 0.53% perc. Similarly, a sample obtained from one industrial cleaner's storage drum tested at 0.15% perc by weight. These samples were taken from the top of the liquid in the storage container. It is possible that the residues contained in the storage container may be stratified, and that the samples collected may not be representative of what the perc concentration is. Two samples taken directly from the still tested 1.50 and 0.2% perc, respectively. For the same reason, as with samples taken from the large storage containers, these results are suspect and the actual perc concentrations may be much higher. A total of five samples were taken under these sampling conditions and their respective perc concentrations may not be representative. Correcting for these samples, the actual number of light oily samples which were within the 0 - 6.9% perc range would be 11 and not the 16 which appears on the graph. This corrected value appears as a dotted line on Figure 2.

Sample results indicated that perchloroethylene concentrations in discarded still bottom residues ranged from 0.02 to 65% perc by weight. The majority of light oily residues were within the range of 25 - 35% perc. Of the heavy still bottom residues 8 of 17, or 45% of the samples were within the 0 - 7% perc concentration range. Similarly, 58% (7/12) of the filter powder samples tested below 7% perc concentration (see Figure 2 a-c).

## VOLUMES OF WASTES GENERATED

During the course of this study, it was found that filter cartridges are a major source of waste from the dry cleaning industry. Moreover, these cartridges may contain a significant amount of perc when discarded into the environment. Since information was collected on the frequency of removal of cartridges, figures estimating the volume of cartridges being disposed of annually in Alberta are also included. However, no cartridges were sampled as to perc content.

After contacting a large number of dry cleaning establishments which were listed in the telephone directories, it was discovered that about 15 - 25% of dry cleaners listed as such do not actually perform any dry cleaning and only act as collection centres or depots. This was true for both rural and urban centres. A middle value of 20% was assumed and used as a correction factor in estimating the actual number of establishments generating solid waste. It was assumed that this value is valid for dry cleaners in all areas of Alberta.

After the actual number of dry cleaners in any given area was determined, it was compared with the number of cleaning establishments visited in that area during the survey and for which concrete data was obtained concerning the amount of wastes produced. Estimates were then obtained for the total volume of wastes generated in that area by multiplying the total volume of wastes generated by a ratio of actual number establishments over the number of establishments visited. This was based on the assumption that the volume and quantity of wastes generated by a the dry cleaners visited is representative of all the dry cleaners in that area.

PERCENT PERCHLOROETHYLENE CONCENTRATIONS FOR 63 LIGHT OILY RESIDUE SAMPLES.

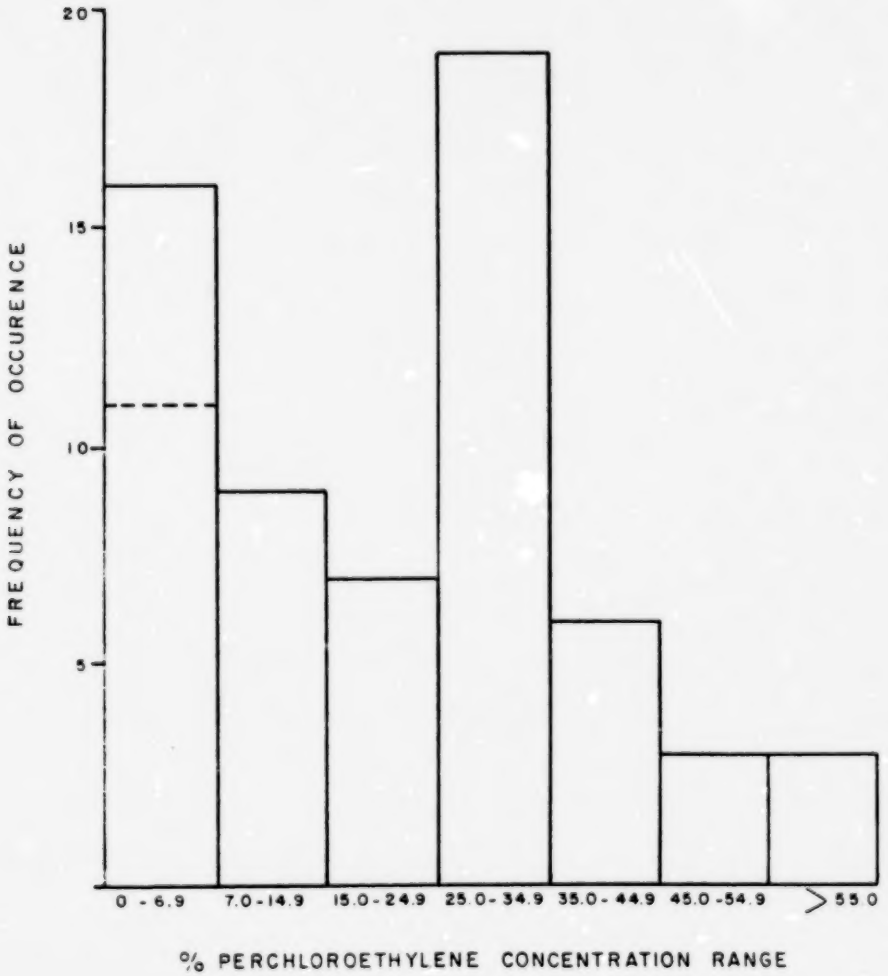


Figure 2(a)

PERCENT PERCHLOROETHYLENE CONCENTRATIONS FOR 18 HEAVY STILL RESIDUE SAMPLES.

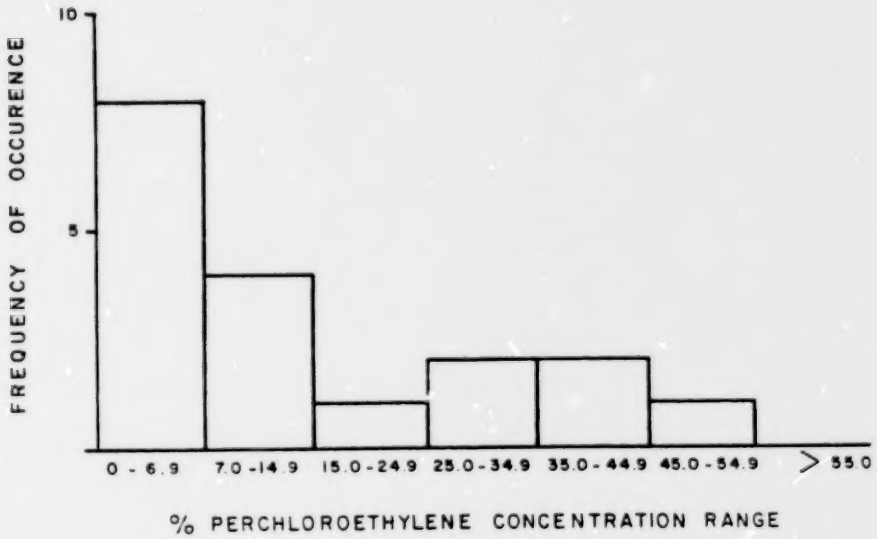


Figure 2(b)

PERCENT PERCHLOROETHYLENE CONCENTRATIONS FOR 12 FILTER POWDER SAMPLES.

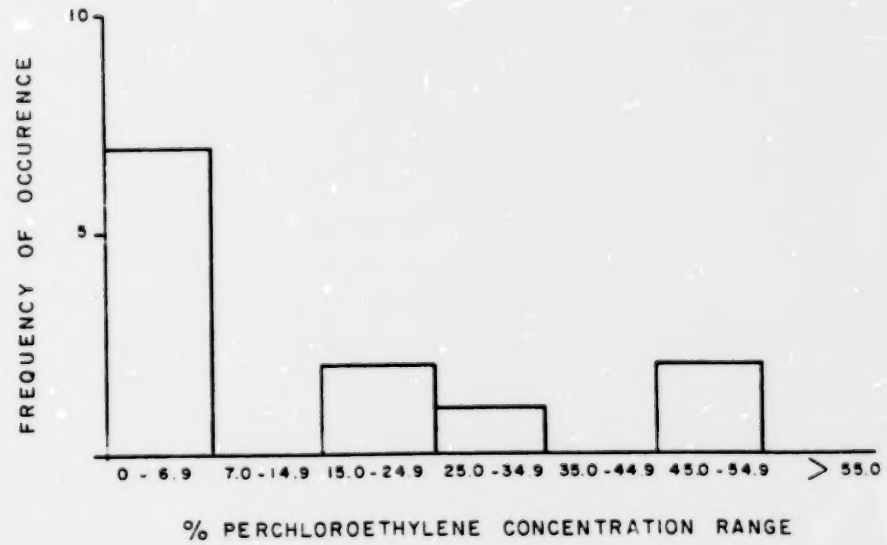


Figure 2(c)

In addition, it was discovered that the summer months are generally the slowest months for the dry cleaning industry. This is due to the fact that throughout the fall, winter and spring months, heavier garments such as sleeping bags and ski jackets constitute a larger portion of the clothes cleaned by the industry. Accordingly, the volume and quantity of wastes generated over this period will also increase. Since the survey was conducted over a 4 month period, from May to August, the volumes of wastes generated at the time of the survey were not representative of the volume of wastes generated during a calendar year.

In reality, the actual volumes of wastes generated during a calendar year are higher. The increases in both business and volume of wastes generated during the fall, winter, and spring months was estimated by the dry cleaners. Consequently, the total volumes of wastes generated were adjusted accordingly to represent this increase. It was assumed that the increase was over a 6 month period.

In addition, for population centres where no actual data was obtained, the volumes and quantities of waste generated were estimated using data from similar population centres and averages determined from previous experience. For example, a value of 4 gallons per month of still residue generated was used in computing the total for the Athabasca & area region. However, for the Grande Prairie and Area region, a 10 gallon per month figure was used. The reason for this is that, the 2 cleaners contacted in that region averaged 10 gallon per month of still residue generated. For the Athabasca & area region, the 2 cleaners contacted averaged 4 gallons per month.

Based on these assumptions, data provided by the survey, and other information from various sources, total volumes of solid wastes generated by the dry cleaning industry in Alberta were calculated. (This would include sub-totals for the various population centres as well as totals for Alberta as a whole. It should be noted that those volumes contributed by industrial cleaners which have their still bottom residues recycled are not included. They were calculated separately. The totals represent only those wastes which are ending up in landfills or dumps across the Province.)

With all of the above data, the Table 1 was developed, which shows the wastes generated per area as well as total wastes generated during current conditions for the year 1986. From Table 1, it can also be seen that an estimated 28,000 - 33,000 gallons of still bottom residues from dry cleaning operations are being discarded into landfills and dumps across the province. In addition, approximately 16,000 - 19,000 cartridges are similarly being disposed of (figures rounded to nearest thousand).

## WASTE DISPOSAL PRACTICES

Virtually all of the dry cleaning establishments visited were disposing their still bottom residues, filter powder and spent cartridge filters into landfills and dumps. The only exceptions were the larger dry cleaning operations, such as industrial cleaners and dry cleaning chains. These operations contained their wastes in storage tanks which were pumped out periodically by oil reclaiming firms. It was discovered that most of the commercial operations disposed of their residues through oil reclaimers.

A typical commercial dry cleaning operation will generate anywhere from 2 - 30 gallons per month of still bottom residue. The average is about 5 gallons per month for most of these operations. The common practice among these cleaners is to store the waste in 5 gallon containers. After the still

TABLE 1

SUMMARY OF CALCULATIONS AND TOTALS FOR ALBERTA

| | CARTRIDGES/YR | REGION | RESIDUE (GAL/YR) |
|---|---|---|---|
| DATA OBTAINED | 5100 - 5600 | Edmonton | 6400 - 6750 |
| | 5700 - 6200 | Calgary | 7300 - 8000 |
| | 910 - 1040 | Lethbridge | 1340 - 1480 |
| | 490 - 550 | Red Deer | 1340 - 1480 |
| | 380 - 420 | Cam/Wet/Led | 540 - 590 |
| | 500 - 600 | Lloydminster | 3500 - 4000 |
| | 280 - 320 | Athabasca | 270 - 310 |
| | 260 - 300 | Drayton Valley | 2000 - 2250 |
| | 850 - 1000 | Grande Prairie | 1350 - 1550 |
| ESTIMATED FIGURES | 700 - 900 | Medicine Hat | 900 - 1200 |
| | 230 - 270 | Barrhead/Morinville | 700 - 1000 |
| | 300 - 400 | Airdrie/Olds | 650 - 950 |
| | 200 - 250 | High River | 450 - 600 |
| | 160 - 200 | Banff | 370 - 480 |
| | 200 - 250 | Ft. McMurray | 1200 - 1500 |
| | 160 - 200 | Brooks | 230 - 270 |
| TOTALS | 16,420 - 18,500 Cartridges/yr. | Alberta | 28,540 - 32,410 gallons/yr. |

These totals only represent those wastes which are ending up in landfills or dumps across the Province.

Estimate for Alberta:
16,000 - 19,000 cartridges/year
28,000 - 33,000 gallons/year

has been emptied of its residue, the waste is put into the container until the container is filled. In urban centres, the container is then placed into a disposal bin along with other general refuse. The same is true with spent cartridge filters. The garbage is eventually disposed of at a landfill. Occasionally, the still residue may be placed in plastic 1 or 2 gallon containers as the still is cleaned, and the residue is again placed in a disposal bin. A number of commercial cleaners would place the residue in a plastic garbage bag and either put the waste into a disposal bin or haul it to the landfill themselves.

Disposal practices in rural areas may differ from those in urban centres. Generally, the waste is usually hauled to the town dump or nuisance grounds by the owner/operator, where the still bottom residue is emptied or discarded with its container. Spent cartridge filters were similarly disposed of. A common practice in these areas was to empty the waste in that portion of the dump where wastes were being burned. Much of the still residue contains oils and greases, along with perc, and will combust easily. However, this method of disposal is not desirable. When exposed to fires, perc produces highly toxic, irritating fumes comprised mostly of hydrogen chloride and phosgene.

Another disturbing disclosure was that at least two dry cleaners were found to be flushing their still bottom residues down the toilet. One of these operations was in a major urban centre and the other was in a rural location. It is hoped that these are isolated incidents, however, we suspect that more cleaners may be disposing of their still bottom residues in this manner.

The industrial cleaning operations generally have a large volume storage tank into which their still residues were discarded. Cartridge wastes are not normally a problem with these operations, as the perc is cleaned solely by distillation. However, industrial cleaners were found to produce anywhere from 80 - 400 gallons of still residue per month. Similarly, franchised commercial operations or dry cleaning chains, which collect the residues from the individual plants and funnel them to the main plant, may collect from 50 - 200 gallons of residue per month. These wastes are then put into a storage tank and are usually pumped out on a bi-weekly or monthly basis by oil recycling firms. However, at least one industrial cleaner, producing approximately 100 gallons of residue per month, was discarding the waste into a nearby modified landfill.

Very few of the commercial operations hauled their residues to the landfill under a manifest. Those that did generally collected a substantial volume (more than 50 gallons) of the residue before hauling it to the landfill. A small number of commercial dry cleaners were storing their residue on site, usually in 45 gallon drums. These cleaners felt that it was not proper to place these residues in a landfill and anticipated that future disposal options were forthcoming.

## CONCLUSIONS

This project included analysis of 93 still bottom residue samples for perc content and gathering information from over 170 dry cleaners across the Province.

Materials listed in Schedule II, List II with a 9.2 designation would have to contain less than 100 ppm of the listed contaminant to be considered a "non-environmental" problem material. Perc can be found in Schedule II, List II of TDGA and as such, cartridges, sludges and diatomaceous earths would have to contain less than 100 ppm of perc to not be regulated by TDGA.

Pursuant to the existing Alberta Hazardous Waste Regulations, only perc solid and liquid wastes containing perc concentrations less than 100 ppm can be landfilled in an approved site. Currently, these regulations are being amended, and the proposed regulations state that perc solid and liquid may be landfilled at an approved site, providing that the perc concentration is not greater than 1000 mg/L (ppm). Under the current and proposed regulations, a hazardous waste manifest must be completed for disposal purposes.

For still bottom residues, this implies that the residue must not contain more than 0.01% perc by weight for that material not to be regulated by the TDGA. None of the samples analysed in the survey tested less than 0.01% perc by weight. Dry cleaners were shown to generate hazardous wastes which should be shipped to appropriate treatment and destruction facilities and meet all the requirements of the Federal Transport of Dangerous Goods Act.

However, it is concluded that waste treatment at the generating source will drastically reduce the amount of perc content in discarded still bottom residues. The operators of dry cleaning businesses can improve their recovery systems to recover more perc and reduce the amount of perc which is released into the environment.

It is recognized that no recycling system will ever recover 100% of the perc. Although an effective pollution disposal system will always be needed, reducing hazardous waste at its source is the most certain way of reducing risks to the environment. In the case of the dry cleaning industry, regulatory agencies cannot count on achieving very large emission reductions from any individual source category. Instead, they must rely on achieving a considerable number of small reductions from a wide range of sources in order to achieve the goal of attaining desired waste disposal standards.